Comment on The Evidence for a Pentaquark and Kinematic Reflections

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PACS numbers: 14.20.-c, 14.20.Gk, 14.80.-j

In a recent article, Dzierba *et al.* [1] discuss the possibility that kinematic reflections, coupled with statistical fluctuations, could mimic the evidence in some photoproduction experiments for the Θ^+ resonance. This is, at first glance, a reasonable criticism where the experimental data can be confronted quantitatively with calculation. However, at a deeper level of examination, there are considerable model assumptions that Ref. [1] has made which warrant closer scrutiny. We shall show that it is doubtful that kinematic reflections of the type given in Ref. [1] can quantitatively account for the pentaquark peak seen in photoproduction experiments such as Stepanyan *et al.* [2] or Nakano *et al.* [3].

The mechanism suggested in Ref. [1] is photoproduction of neutral $f_2^0(1270)$ and $a_2^0(1320)$ tensor mesons (with subsequent decay into K^+K^-) for the reaction $\gamma d \to K^+K^-pn$, to produce a broad enhancement in the mass spectrum of the nK^+ system. Although their calculation cannot reproduce the narrow peak shown in Ref. [2], the statistics are low and fluctuations of this broad enhancement might result in a false narrow structure. There is no estimate in Ref. [1] for the probability of such a fluctuation, assuming their model is correct.

The reaction model in Ref. [1] uses t-channel Regge exchange amplitudes which has been studied for charged a_2^+ photoproduction (see Ref. 10 of their paper). They use the same model for neutral a_2^0 and f_2^0 photoproduction, and compare their calculation to the data of Ref. [2], as described above. The exchange particle in this model is the pion (and its higher-mass partners on the Regge trajectory line). However, the neutral π^0 itself cannot participate in this trajectory, since this vertex is forbidden by C-parity (the π^0, f_2^0 and a_2^0 all have positive C-parity, whereas the photon has negative C-parity). The fact that the lowest mass exchange particle cannot participate drastically alters the Regge amplitudes. For example, in charged a_2^+ production, the pion pole is known to dominate the Regge amplitudes at photon energies of a few GeV. When the pion amplitude is dropped, the calculated cross section for a_2^0 and f_2^0 production is lower by over an order of magnitude [4, 5].

It is interesting to note that Ref. [1] does not take the resonance parameters from charged a_2^+ photoproduction. In fact, they fit the parameters in their model to the nK^+ spectrum of Ref. [2]. Can we trust these exchange resonance parameters? One serious concern is that Ref. [1] did not take into account the detector acceptance. The parameters extracted from fitting the raw spectrum of Ref. [2] without acceptance corrections are unlikely to represent the underlying physics correctly. In a predictive calculation, these parameters would be fit to an independent data set for photoproduction of f_2^0 and a_2^0 production, as extracted from the K^+K^- decay spectrum, and then applied to the nK^+ spectrum of Ref. [2].

The most curious aspect of the calculation in Ref. [1] is the value of the cross section. As shown in Fig. 4 of Ref. [1], the peak in the calculation near 1.25 GeV is due to the $f_2(1270)$ and the $a_2(1320)$. The broad background is presumably due to nonresonant P-wave production. Again, the parameters have been fit to the nK^+ spectrum, and not the K^+K^- spectrum. This is odd, considering that the a_2 and f_2 decay into K^+K^- whereas the nK^+ spectrum depends on many factors (including the Fermi momentum). Clearly, if the authors of Ref. [1]

had fit the K^+K^- spectrum instead, the contribution of a_2 and f_2 would be much reduced.

Furthermore, the reaction mechanism used in Ref. [1] assumes that some helicity states of the tensor mesons are preferentially excited. In essence, their model assumes that the tensor mesons are polarized, even though the initial photon beam (and the target) are unpolarized. The population of particular m-substates of the tensor mesons results in an angular distribution which, when integrated over all space, gives a minimum which is reflected in the (nK^+) mass spectrum. However, it has not been shown by any data to our knowledge that the a_2 and f_2 tensor mesons are produced in a polarized state in the helicity frame, as Ref. [1] assumes when using a nucleon-flip pion exchange reaction mechanism. Without this untested model assumption, the broad peaks in the nK^+ mass spectrum of Ref. [1] go away.

We wish to state that, *apriori*, we do not reject the suggestion that kinematic reflections exist, nor do we dismiss the possibility that the peak seen in Ref. [2] might be due to kinematic reflections. The point is that the a_2^0 and f_2^0 are not likely candidates for this. In any case, the K^+K^- invariant mass spectrum is a much better starting point to determine these contributions, rather than fitting the nK^+ spectrum as was done in Ref. [1]. Finally, reaction mechanisms that depend on preferential production of polarized m-substates from unpolarized beam and target should be confronted with data.

To conclude, the calculated mass spectrum of Ref. [1] is not likely to survive a careful quantitative comparison with the data of Ref. [2]. At the very least, one can say that there is considerable model-dependence in Ref. [1]. We believe it is fair to question the authors of Ref. [1] for the validity of their conclusions, especially considering that the dominant pion pole cannot contribute to their Regge amplitudes.

We acknowledge useful comments from Ya. I. Azimov regarding C-parity conservation at the photon vertex.

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